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Carnivores and Corridors in the Crowsnest Pass

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Alberta Species at Risk Report No. 50

Alberta
SUSTAINABLE RESOURCE DEVELOPMENT

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Carnivores and Corridors in the Crowsnest Pass

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EXECUTIVE SUMMARY

Habitat loss, fragmentation and subsequent isolation of habitat patches due to human activities are major factors contributing to species endangerment. Large carnivores such as grizzly bears and cougars are particularly susceptible to fragmentation because they are wide-ranging and exist at relatively low population densities. Conservation strategies have focused primarily on preserving intact habitats within protected areas and maintaining or restoring ecological connectivity across the multiple-use landscape between protected areas. However, tools to predict how habitat-use and movement patterns of large carnivores may change in response to increasing anthropogenic activities such as suburban expansion, recreation, and the development of highways outside of protected areas are lacking. Local land management authorities (municipalities, municipal districts, and the provincial government) and conservation organizations require empirical data and predictive tools to make and support land-use decisions that affect ecological connectivity for carnivores and their prey in areas with escalating development pressures.

To address this issue, I developed a research project to compile existing data on habitat, human use, and ungulate prey species and conduct new ecological research on habitat selection and movement patterns of grizzly bears and cougars. By comparing habitat values at the locations obtained from Global Positioning System (GPS) collars placed on grizzly bears and cougars to those at random sites, Resource Selection Function (RSF) models will be developed to determine the probability of occurrence of grizzly bears and cougars. GPS location data will be analyzed to quantify movement patterns of collared individuals given current landscape conditions and modeled as a function of the same variables developed for the RSFs to predict where the highest probability of a particular type of movement will occur. A Geographic Information System (GIS) will be used to model both the probability of occurrence and movement characteristics for each animal given current and proposed development scenarios. High probability of use and type of movement can be used to locate and assess the most suitable locations for corridor placement.

Briefly, research has progressed on three fronts:

1. ***Developing a landscape map for carnivores in the Crowsnest Valley.*** Digital data continue to be acquired through a cooperative data sharing agreement with ASRD. The following digital data layers have been obtained: townsites; roads and trails; Wildlife Management Units (WMUs); Alberta Vegetation Index (AVI); hydrography; aerial photographs; and critical wildlife areas. Greenness and a Digital Elevation Model (DEM) were acquired, courtesy of the Miistakis Institute, through Clayton Apps. Layers have been compiled in a GIS.
2. ***Collecting data on habitat selection and movement patterns of grizzly bears and cougars in the Crowsnest Pass.*** During 2001/02, in cooperation with ASRD, I captured five cougars (three females and two males). These cougars were fitted with GPS collars. A female cougar was killed by a hunter in February, a male slipped his collar in May, and VHF contact was lost with a male and female. Movement data were obtained for three of these cougars. In April-June, in

cooperation with ASRD, I captured two male grizzly bears. One male had previously been captured as part of an ongoing monitoring project of problem bears. He slipped his collar in June. The second male remains collared and is currently denned. Movement data were obtained for both of these bears either from the collar directly or via a remote download. Telemetry data from the ongoing monitoring project of problem grizzly bears was plotted in ArcView. Historical data on sightings, occurrences, road mortalities, and hunting statistics in the study area were compiled for grizzly bears and cougars.

3. ***Compiling existing telemetry and distribution data for ungulates in the Crowsnest Pass.*** Historical and current annual reports for elk, bighorn sheep and goats have been reviewed. Data on population trends, sex and age composition, and distribution have been compiled and will be imported into a GIS for development of a digital density layer and prey indices. Hunting registrations were compiled when available.

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I thank Kirk Olchowy, John Clarke, and the conservation officers in Blairmore. Their efforts and expertise made for a safe and successful cougar and grizzly bear field season. I also thank the conservation officers in the Pincher Creek office for their assistance in cougar and grizzly bear captures and for collecting measurements on cougars registered in Pincher Creek.

I thank the houndsmen and their dogs who participated in the cougar capture operations: Mike Chodyka, Jake Collings, Jeff Davis, Dale Kropinak, and Fiore Olivieri. In addition, Eric Muff participated in one of our capture operations. Their interest, hard work, and expertise were instrumental to a successful cougar field season.

Greg Goodson and the pilots with Bighorn Helicopters provided safe and reliable helicopter support for telemetry flights. Dr. Sonja Legendre, D.V.M. provided access to blood analyses equipment, facilitated drug paperwork, and provided a portable oxymeter for our grizzly bear captures. Lana Robinson, SRD, provided digital data and aerial photographs under a data sharing agreement and Clayton Apps also provided digital data courtesy of Miistakis Institute.

In addition to the generous support from the Alberta Species-at-Risk Program, funding was provided by: Alberta Conservation Association (ACA)-GECF, the Wilburforce Foundation, the Wildlife Conservation Society, Devon Canada Corporation (formerly Northstar Energy Inc.), Shell Canada Ltd., the Nature Conservancy of Canada, the Boone and Crockett Club, and Dr. Mark Boyce, ACA Chair in Fisheries and Wildlife. Cheryl Chetkiewicz was the recipient of an Alberta Ingenuity Fund studentship and the University of Alberta Bill Shostak Wildlife Award (2001/02).

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1.0 INTRODUCTION

This document was developed under contracts to the Alberta Sustainable Resource Development Agreement Nos. PR01-5033 and No. PR02-3059. The terms of reference for this report issued under these contracts were as follows:

1. Conduct a review of selected scientific literature on carnivore biology and conservation, the responses of grizzly bears and cougars to human activities, and relevant corridor and fragmentation studies and present in a report.
2. Develop project design for a 3-year study modelling and measuring actual carnivore use in Crowsnest Pass, to determine preferred habitats and movement corridors, and to verify areas for habitat securement and present in a report.
3. Continue compiling existing habitat, land-use, and wildlife data into one centralized database and develop a working basemap for the Crowsnest Pass area.
4. Capture cougars and instrument with GPS collars (December 2001 – February 2002); establish research and capture plans for grizzly bears (March 2002), and capture grizzly bears and instrument with GPS collars (April – June 2002).

2.0 BACKGROUND AND LITERATURE REVIEW

2.1 Carnivore Biology and Conservation

Habitat loss, fragmentation and the isolation of habitat fragments due to human activities are major threats to the conservation of biodiversity (Wilcox and Murphy 1985). Drawing from the theory of island biogeography (MacArthur and Wilson 1967) and metapopulation models (Hanski and Gilpin 1991), conservation strategies to counter the effects of fragmentation has focused on preserving intact habitats and maintaining ecological connectivity between them. Landscape ecology incorporates the concepts of spatial heterogeneity, edges, patches and scale. Landscapes incorporate the patterns and processes of ecological interactions between communities or ecosystems and are considered to be appropriate units for management and conservation actions (Turner 1989). Landscape ecology and the quantitative techniques and models developing in association with this evolving discipline are essential tools for describing and ameliorating the effects of habitat destruction and fragmentation (Turner and Gardner 1991).

Large carnivores such as grizzly bears and cougars have been proposed as surrogate species for biodiversity conservation strategies (Lambeck 1997). The effects of large carnivores on prey, other carnivores, and vegetation are considered important in structuring and maintaining biodiversity within terrestrial communities (Terborgh et al. 1999). They are considered to be umbrella species because they have large home ranges that may encompass populations of species with smaller home ranges (Noss et al. 1996, *but see* Andelman and Fagan 2000). Mammalian carnivores, however, are sensitive to changes in landscape structure due to their low population densities, low fecundity, and their limited dispersal ability across open or developed habitats. Consequently they are susceptible to habitat fragmentation, particularly due to human activities (Weaver et al. 1996). Due to their life history traits, large carnivores rarely remain within the

boundaries of protected areas that are often too small to conserve viable populations or contain enough suitable habitat to support these animals throughout the year (Noss et al. 1996). Large carnivores that move outside or along the edges of protected areas experience high mortality rates due to conflicts with humans (Woodroffe and Ginsberg 1998). Increasing anthropogenic pressures from industry, recreation, and suburban and highway expansion outside of protected areas may restrict individual movements and population viability and exacerbate the conflicts between humans and wildlife. Carnivore conservation strategies to offset these effects have focused on the development of regional reserve networks consisting of protected areas, buffer zones, and wildlife corridors that facilitate movements between protected areas (Soulé and Terborgh 1999).

2.1.1 Movement

Movement of individuals is fundamental to a host of ecological processes such as population spread and redistribution (Turchin 1998), metapopulation dynamics (Hanski 1998), local species richness (Fahrig and Merriam 1994), local and regional population dynamics (Kareiva 1990, Dunning et al. 1992), inbreeding depression and opportunities for local adaptation (Hastings and Harrison 1994). Movement paths reflect an individual's behavioral response to the environment at a variety of temporal and spatial scales and are therefore critical to assessing and understanding the impact of changes in landscape structure. Movement among patches is a function of the organism's use, ability to move, and movement rates among patches as well as the landscape structure itself. This interaction has been defined as connectivity which is the degree to which a landscape facilitates or impedes movement of organisms among resource patches resulting in recolonization and/or local extinctions of populations (Tischendorf and Fahrig 2000). Quantitative methods for the study of animal movement have been established (Turchin 1998). The majority of the empirical work on movement has focused on invertebrates (Turchin 1998).

Kozakiewicz and Szacki (1995) reviewed the information on small-mammal movements in heterogeneous landscapes. They suggested that most of the literature was devoted to documenting dispersal and population consequences, but individual movements were rarely documented making it difficult to understand the patterns at the population level. Data on movements within home ranges were inconsistent between studies and the results depended strongly on the methods used to either collect the data or analyze the information. They noted that the scale at which the studies were conducted (< 1 ha) had biased the understanding of movement and population-level processes and patterns in that there was considerable mobility of small mammals and the greater the heterogeneity, the greater the mobility. They felt different species of small mammals had different strategies for dealing with landscape heterogeneity. Stern (1998) reviewed the effects of landscape structure, scale, and movement in field experiments with large mobile organisms. He suggested that the study of mobility in large organisms was really the study of individuals and models were necessary to address dynamics at more realistic spatial and temporal scales. Even with conventional telemetry, the quantitative measurement of movement is rarely addressed (Turchin 1998). With the advent of GPS collars, the opportunity to obtain frequent and accurate relocations of large mammals and the reconstruction of movement paths at a variety of spatial and temporal scales is

possible. Although we can quantify different types of movement (daily and seasonal movements as well as long-distance movements), the roles of biotic and abiotic factors affecting the movement of individuals, whether large or small, are not well understood (Turchin 1998, Gilliam and Fraser 2001). Landscape structure modeled within a GIS provides a realistic approach to assessing animal movement and the potential effects of management or conservation actions on animal movement and population dynamics can be examined (Folse et al. 1989, Turner et al. 1993, Liu et al. 1995, Rushton et al. 1997, Stern 1998, Wei and Jeske 2000).

2.1.2 Wildlife Corridors

Corridors are thought to enhance long-term survival of populations by facilitating movement of individuals to reduce the vulnerability of insular populations to stochastic extinction and provide a means for recolonization by permitting dispersal and allowing animals to escape unfavorable conditions within patches (Brown and Kodric-Brown 1977, Simberloff and Cox 1987, Noss 1992, Fahrig and Merriam 1994, Rosenberg et al. 1997). Corridors are not consistently defined, but typically mean linear, continuous strips of habitat that connect two otherwise non-contiguous habitat patches (Saunders and Hobbs 1991, Hobbs 1992, Jalkotzy et al. 1997). Corridors can be natural or remnant features such as hedges and riparian strips (Bennett et al. 1994) or disturbed features resulting from human activities such as linear developments like roads, logging buffers, and powerline strips (Schmiegelow et al. 1997, Jalkotzy et al. 1997). They can function in a number of ways: habitat, conduits, filters or barriers, sources, and sinks (Merriam 1991, Jalkotzy et al. 1997). Wildlife corridors are considered to be most useful if they can facilitate movement and as such they are usually defined as transitional habitats (Soulé 1991). The more similar the corridors are to the patches that they connect, the more effective they will be in functioning as conduits for daily, seasonal and long-distance movements such as dispersal and migration (Lidicker, Jr., and Koenig 1996).

Observational, experimental, and modeling approaches have been applied to address the value and utility of corridors for different species, particularly small mammals, birds, and insects (Rosenberg et al. 1997, Beier and Noss 1998, Haddad et al. 2000). However, statistically robust experiments to test the effects of corridors at the scale appropriate for large mobile mammals like carnivores are considered too expensive, labor-intensive and not practical under many circumstances (Nicholls and Margules 1991, Inglis and Underwood 1992). Though the value and utility of corridors remains scientifically debatable (Simberloff and Cox 1987, Noss 1987, Hobbs 1992, Simberloff et al. 1992), they continue to be promoted in the conservation literature as a practical approach to management (Little 1990, Hudson 1991, Smith and Hellmund 1993) and conservation (Noss 1983, Saunders and Hobbs 1991).

One source of semantic confusion is the concept of connectivity. Connectivity is defined as the degree to which a landscape facilitates movement of individuals among resource patches (Taylor et al. 1993, Tischendorf and Fahrig 2000). Tischendorf and Fahrig (2000) suggested that corridors may be a component of landscape connectivity, but the degree to which they contribute to connectivity depends on the nature of the corridors, the nature of the matrix and the response of the organism to both (Rosenberg et al. 1997,

Beier and Noss 1998). Connectivity is both species- and landscape-specific and must be described from the species' point of view (Wiens and Milne 1989). Consequently, it is important to define the species' habitat or resource needs; determine the scale at which the species' is responding to the landscape at both the fine-scale (grain) and large-scale (extent) (Wiens 1991); and, assess how the species responds to the different elements and changes in the landscape at different scales.

Designing corridors is complicated because of the difficulty in addressing species and scale specific details, conflicting land use policies on the landscape, and the cumulative effects of different land uses on individuals and populations (Merriam 1995, Beier and Loe 1992, Paquet et al. 1994, BCEAG 1999). The quantity and quality of the corridor in facilitating movement for target species can be generalized to include the quality of the habitat that the corridor connects, the location of the corridor, its width, length, and shape, the availability of cover, the ease of travel, the level and type of human use within and adjacent to the travel route, and the extent to which users of the corridor are habituated to human developments and activity (Heuer 1995). However, managers must often define and secure wildlife corridor designations without site-specific empirical data on resource selection and movement patterns of target species. Having these data is important since different species react differently to the availability and quality of corridors and the human induced changes, activities, and developments on the landscape (Jalktozy et al. 1997).

3.0 RESPONSES OF GRIZZLY BEARS AND COUGARS TO HUMAN ACTIVITIES

3.1 Grizzly Bears and Human Activities

Grizzly bears are the most omnivorous large carnivores. They require habitats with high quality seasonal food resources that allow them accumulate enough fat reserves for hibernation (Weaver et al. 1996). The persistence of grizzly bear populations in the southern Canadian Rocky Mountains and the contiguous United States is linked to human-caused mortalities and human impacts on grizzly bear habitats (Bunnell and Tait 1981, Servheen 1990, Stringham 1990, McLellan 1994). In general, grizzly bears are sensitive to human disturbance and activities as well as human developments, particularly roads (McLellan 1990, Weaver et al. 1996, Jalkotzy et al. 1997). Jalkotzy et al. (1997) provided an excellent review of the effects of human activities, specifically linear developments such as roads, railroads, and highways on grizzly bears. Mattson et al. (1996) also highlighted the effects of human activities, particularly roads, on grizzly bear behavior and habitat use.

Intensive grizzly bear studies have been conducted throughout the province including: South Wapiti, Swan Hills, Berland Wildhay, Jasper National Park (JNP), BNP, Kananaskis Country, and Waterton Lakes National Park (summarized in Nagy and Gunson 1990). More recently, grizzly bears were studied in the Bow River Watershed (Gibeau 2000), the Yellowhead Ecosystem (Stenhouse and Munro 2000), and southwestern Alberta (Mowat and Strobeck 2000). In Alberta, grizzly bears are forced into higher elevations as industrial and recreational development, roads, and suburban

expansion now characterize the more productive grizzly bear habitat at low elevations. In addition, the mountain national parks in Alberta do not provide adequate quantities of prime grizzly habitat. For example, only 53% of BNP is considered suitable grizzly bear habitat, which is further reduced by townsites, roads, recreational developments, and human use within the Park (Green et al. 1996).

In Alberta, the relationship between grizzly bears and agricultural, industrial and recreational development has been documented (McCrory and Herrero 1982, Horejsi 1986 cited in Apps 1993, Herrero et al. 1986, Nagy and Gunson 1990). Purves et al. (1992) reported that human-use levels in Banff, Yoho, and Kootenay National Parks exceeded the tolerance of non-habituated bears resulting in habitat avoidance. Gibeau (2000) and Gibeau and Heuer (1996) documented the effects of highways on grizzly bear movements and found that the Trans-Canada Highway (TCH) was an effective barrier for adult females as no radiocollared females crossed the TCH and a filtered barrier for adult males. Clevenger and Waltho (2000) analyzed carnivore activity at eleven wildlife underpasses in BNP and found carnivore use in general was positively correlated with distance to townsites and negatively correlated with human use around or in underpasses. Grizzly bears did use two of the underpasses. Grizzly bears also suffer direct morality due to human activities such as hunting and problem responses and in collisions on highways and railroads (Gunson 1995).

A cumulative effects model (CEM) was developed for grizzly bears in BNP and JNP in Alberta, and Yoho and Kootenay National Parks in British Columbia (Green et al. 1996). This model created an index of habitat effectiveness for each bear management unit within the Parks given habitat quality and human disturbance. It was based on grizzly bear food habits and habitat use studies within the Parks and human disturbance values adopted from the Yellowstone ecosystem. Herrero and Herrero (1996) used this model to address the effects of a coal pit mine in west central Alberta. The CEM approach was extended to model bear dispersal paths in BNP and surrounding area with a Linkage Zone Prediction (LZP) model. The LZP predicts the relative probability of grizzly bear movements given human development features (towns), linear disturbance elements (roads, railroads), visual cover, and riparian habitat. It was not based on any empirical grizzly bear movement data for the area since none existed at the time (Green et al. 1996). An LZP approach was also applied to Highway 3 in both southeastern BC and southwestern AB (Apps 1997).

3.2 Cougars and Human Activities

In general, cougars are tied to cervid populations, their main prey, therefore management, protection and enhancement of habitats for cougar prey populations are considered important to sustaining cougar populations (Carroll et al. 2000). Cougar habitat can be characterized by the presence of sufficient prey that is deer-sized or larger and terrain that facilitates predation on that prey (e.g., snow and cover).

In Alberta, cougars are a management and conservation concern (Yellow B List). Only one intensive cougar study has been conducted in Alberta. From 1981-1989, the Sheep River Cougar Project investigated cougar ecology in the foothills of the Rocky Mountains

in southwestern Alberta (Ross and Jalkotzy 1992) providing the scientific basis for the Alberta Cougar Management Plan (Alberta Fish and Wildlife 1992). Jalkotzy and Ross (1991) also summarized the available data on cougars within Alberta's National Parks.

Limited scientific data is available on cougar responses to human activities (Weaver et al. 1996, Jalkotzy et al. 1997). In Alberta, Jalkotzy et al. (1999) found male and female cougars avoided areas of high human use (250-500 users/month) throughout the year in the Sheep River study area, but did not avoid low-use trails and roads in the winter. Cougars suffer direct mortality through hunting especially when winter snowtacking conditions facilitate locating and hunting cougars. For example, the Albertan cougar harvest seemed to be linked to the degree of motorized access (Jalkotzy et al. 1997). Existing highway underpasses in Canmore and BNP appear to function for cougars (Clevenger 2000, Clevenger and Waltho 2000, Gibeau and Heuer 1996). Callaghan and Jevons (2001) reported that cougars adjusted well to human activity in their corridor study area and suggested that cougars may benefit from human activity as domestic dogs were documented as being prey items.

4.0 WILDLIFE CORRIDORS: BEARS AND COUGARS

4.1 Grizzly Bears

Mattson et al. (1996) suggested that there was no evidence that North American grizzly bears populations were characteristically fragmented or exhibited a metapopulation structure prior to the arrival of Europeans. Mortality of grizzly bears associated with human access has been described as a source-sink model where areas near human facilities are considered sinks and parks are considered sources (Doak 1995). Nagy and Gunson (1990) postulated that this was the structure of grizzly bear populations in southern Alberta. Increasing the exchange between small, otherwise vulnerable populations is theoretically good for grizzly bears (Harrison 1991). Noss (1992) suggested that functional linkage corridors for grizzly bears should be about twice the width of the mean life range of an adult male. Mattson et al. (1996) felt that the functionality of corridors could only be considered when populations were within a range of lifetime movements. Populations isolated from each other beyond these distances will not benefit from corridors as currently defined. There is limited data on dispersal for grizzly bears and long distance movements of male grizzly bears (Blanchard and Knight 1991, Boone and Hunter 1996, Craighead and Vyse 1996). Ruckelshaus et al. (1997) showed that errors in estimating these distances had important consequences for model results.

Picton (1986) suggested that a functional linkage ("corridor") was possible between the Yellowstone and Glacier National Park area. Bader (2000) conducted a spatial analysis of grizzly bear populations in the US Rockies using a minimum corridor width for males and females based on broad habitat categories (mesic (South Fork Flathead, Selkirk and Cabinet-Yaak) and xeric (Yellowstone and Rocky Mountain Front areas)). His analysis of potential linkages combined with dispersal distances showed that secure areas were spatially distributed within known dispersal distances for male and female grizzly bears.

In Alberta, most of the research on corridor use is based in BNP or in the Canmore corridors takes place during the winter months using snowtracking techniques (Heuer 1995, Stevens et al. 1996, Heuer et al. 1998, Duke 2000, Callaghan and Jevons 2001). Consequently, there is little data on the summer use of these corridors by grizzly bears.

4.2 Black Bears

Several studies suggest that black bears use corridors both for seasonal movements and dispersal. Kellyhouse (1977) and Weaver et al. (1990 cited in Harris et al. 1996) found that bears used riparian strips to move within fragmented strips. Manville (1983) reported that linear developments were serving as travel corridors for black bears in Michigan. Beecham (1983) showed that migration corridors within this study area were important for maintain black bear populations in Idaho. Mollohan and Lecount (1989 cited in Harris et al. 1996) showed that canyons with suitable cover were used by black bears during seasonal foraging trips.

In Alberta, most of the research on corridor use is based in BNP or in the Canmore corridors takes place during the winter months using snow-tracking techniques (Heuer 1995, Stevens et al. 1996, Heuer et al. 1998, Duke 2000, Callaghan and Jevons 2001). Consequently, there is little data on the summer use of these corridors by grizzly bears.

4.3 Cougars

The use of corridors and remnant habitat patches by cougars has been intensively studied in Florida (Maehr and Cox 1995, Maehr 1990). Landscape structure and cougar radio data locations were analyzed to identify what lands and habitat variables were important for cougar conservation. The authors did not designate wildlife corridors for cougars nor did their analyses reveal any minimum functional corridor dimensions. Cougars used bands of remnant forest as narrow as 100 m as they moved through the agricultural and urban landscape (Maehr 1990).

In southern California, Beier (1993, 1995, 1996) documented the use of three remnant corridors and several habitat patches by resident and dispersing cougars that were semi-isolated by urbanization. Five of the nine dispersers found and used these corridors. He documented their movements with respect to roads and found that topography and vegetation were critical in determining the quality of the corridors for cougars. The locations of these corridors were critical with respect to road crossings. Beier (1993, 1996) simulated the resulting population dynamics for this population. He showed that for best estimates of parameters, the population faced a 3% risk of extinction in the next 100 years with current amount of habitat. Reducing the habitat by 40% (a likely scenario) increased the probability of extinction to 33%. The results suggested that fragmentation would be detrimental to local populations and remnant corridors had to be maintained if these populations were to persist. In this study, the results of the field data and a quantitative model were used to restore and protect these corridors.

Ruth et al. (1998) monitored the movements of translocated cougars in New Mexico. These animals often moved along the urban-wildland interface in remnant corridors. Ruth et al. (1998) recorded the movement behaviors in response to obstacles and barriers

and used these data to suggest that barriers for translocated cougars had similar ramifications to naturally dispersing cougars in the region.

Sweanor et al. (2000) examined cougar dispersal, emigration, and immigration to assess the effects of dispersal on the local and surrounding metapopulations. They examined movements across potential barriers such as highways and the use of remnant habitat corridors along the mountain ranges. They did not identify distinct habitat corridors but inferred that their study areas functioned as "corridors" depending on the dispersal success.

In Alberta, Heuer (1995), Stevens et al. (1996), Heuer et al. (1998) and Duke (2000) documented cougar use in four areas subject to medium and high levels of human use where movements were restricted because of the TCH. Snow tracking within these four corridors indicated that cougars preferred to use the Norquay-Cascade remnant corridor that was 200 – 800m wide and 8 km long (Stevens et al. 1996). Callaghan and Jevons (2001) documented winter cougar use in a remnant corridor in the Canmore region of the Bow Valley.

5.0 GOAL AND OBJECTIVES

Habitat loss, fragmentation and subsequent isolation of habitat patches due to human activities are major factors contributing to species endangerment. Large carnivores such as grizzly bears and cougars are particularly susceptible to fragmentation because they are wide-ranging and exist at relatively low population densities. Conservation strategies have focused primarily on preserving intact habitats within protected areas and maintaining or restoring ecological connectivity across the multiple-use landscape between protected areas. However, tools to predict how habitat-use and movement patterns of large carnivores may change in response to increasing anthropogenic activities such as suburban expansion, recreation, and the development of highways outside of protected areas are lacking. Local land management authorities (municipalities, municipal districts, and the provincial government) and conservation organizations require empirical data and predictive tools to make and support land-use decisions that affect ecological connectivity for carnivores and their prey in areas with escalating development pressures.

The **goal** of my research is to locate and quantify the features of wildlife corridors for grizzly bears (*Ursus arctos*) and cougars (*Puma concolor*) in the Crowsnest Pass. Grizzly bears have a high conservation and management interest in Alberta and in Canada and the United States. They have large home ranges, exist at relatively low population densities, and require adequate prey populations. They are susceptible to local extinction in existing protected areas and typically subjected to high mortality rates outside and on the edges of these areas due to conflicts with humans. Grizzly bears are classified as vulnerable at the Federal level and have been recommended for threatened status in Alberta by the Endangered Species Scientific Committee. Cougars were identified as a species of special concern by COSEWIC and the Alberta Government (Blue List). Cougars have a high management interest in Alberta. Cougar populations in Alberta currently face many of the threats identified by COSEWIC for eastern cougars and

as such have been identified as a species warranting special management concern by the Alberta Government (Yellow B List) because of population status and human disturbance.

My **primary objective is to develop resource selection functions and movement models at different spatial and temporal scales for grizzly bears and cougars to locate and characterize corridors in the Crowsnest Pass**. In collaboration with SRD, data on individual movements will be obtained from cougars and grizzly bears equipped with GPS collars. Landscape heterogeneity will be quantified in a GIS using available data from remote sensing and existing digital data layers for habitat data e.g., greenness, habitat type, landscape data e.g., elevation, slope, aspect, distance to stream, and human use data e.g., road and trail densities, distance to human point features.

My **secondary objective is to use empirical data and the predictions from resource selection function (RSF) and movement models to evaluate existing corridor designations within the Crowsnest Pass**. Crowsnest Pass is considered to be an important link for carnivore populations in the United States and the Canadian Rocky Mountains and the narrowest strip of forest along the Rocky Mountains (Apps 1997, Herrero 1998, Miistakis Institute for the Rockies 1998). Three corridors have been identified by SRD based on apparent landscape connectivity, wildlife occurrences, and direct observations of wildlife. I will assume that the areas predicted by the RSF and movement models generated during my research are the most suitable areas for these species given current landscape conditions. I will compare these predictions with the currently designated corridors and address various development scenarios anticipated for each landscape. I anticipate that these results will be used to focus and prioritize local and regional habitat retention and protection efforts, identify and validate wildlife habitat and movement corridors, and provide empirical data for placement of structures to mitigate anticipated highway twinning in the Crowsnest Pass.

6.0 STUDY AREA

The study area includes the Crowsnest River Valley in southwestern Alberta, up to the border with British Columbia, and includes private and crown land adjacent to the communities of Blairmore, Bellevue, Frank, Hillcrest, and Coleman. It encompasses approximately 7,628 ha though the capture efforts focus on Wildlife Management Unit (WMU) 303, approximately 1,647 km^2. The region is biologically diverse as it occurs at the intersection of a number of natural subregions including montane, subalpine foothills parkland and foothills fescue grasslands. Land use in the region has intensified to include large ranches, forestry, and recreation. Highway 3, a two-lane transportation route, and a railroad follow the river valley and support the Crowsnest Pass communities, now established urban centers.

7.0 METHODS

Generally, activities during 2001/02 focused on establishing a rapport with SRD staff in Crowsnest, familiarizing myself with the study area, developing a data-sharing agreement with SRD to obtain digital data layers for the study area, locating, reviewing, and

compiling existing reports and data on grizzly bears, cougars, and ungulate prey, capturing and collaring cougars and grizzly bears and fund raising. All animal care protocols were reviewed and approved by SRD and the University of Alberta Animal Care Committee. Permits were obtained annually from SRD.

7.1 Cougar Captures

Ridge tops, roads, powerlines, and trails were searched by truck, snowmobile, all-terrain vehicles and on foot by local houndsmen and researchers to locate cougar tracks. Search effort depended on snow conditions and availability of personnel and we did not pursue kittens or adults traveling with kittens. When fresh tracks were found, trained hounds were used to tree the cougar. Treed cougars were darted using the Palmer Cap-Chur rifle and/or pistol. Darts contained a premixed 2:1 ratio of ketamine hydrochloride (KHCl) at an intended dosage of 5 mg/lb (11 mg/kg) and xylazine hydrochloride (XHCl) at an intended dosage of 2.5 mg/lb (5.5 mg/kg). When an immobilized cougar remained in the tree, several minutes were spent observing the cat for signs of induction. Once the cougar could be approached safely, I ascended the tree. Changes in the cat's condition were reported by the ground team during the ascent to ensure human and animal safety. A rope was attached to the hind foot and the cougar was then belayed slowly to the ground. On all but one occasion, the darted cougar jumped from the tree and ran away. In these cases, it either ascended another tree or remained on the ground. It was subsequently tracked to the location where it became immobilized. Induction time, time between injection and when the cougar could be handled safely, and immobilization time, time from induction to when the cougar first attempted to rise, were recorded whenever possible. Effective dosage was measured using the measured weight and the total amount of drug administered.

Each individual was placed on a tarpaulin and hobbled. The cat was positioned to allow it to breathe easily and its head was placed slightly lower than its body to allow excess saliva to flow easily. An ophthalmic lubricant was placed in the eyes and the eyes were covered. Vital signs (respiration rate and rectal temperature) were monitored every ten minutes throughout the procedure. Darts were removed and the wound was examined and treated. Cougars were thoroughly examined for injuries. Cougars were sexed, weighed, and measured following Pall et al. (1988). Cougars were aged using gum line recession (Laundré et al. 2000) and assigned to one of two age categories based on body size and teeth conditions: 1) adult (> 2.5 years); and, 2) sub-adult (< 2.5 years). Adult females were checked for signs of lactation and nipple distension. SRD standard orange research tags were placed in the appropriate ear, right for females, left for males. Tissue and hair samples were collected. Blood samples were taken when possible for health analyses. Cougars were fitted with a Televilt GPS-Simplex™ collar (Model G01-01022) (Appendix A). Following handling, the cougar was moved to a flat and shaded area and oriented slightly downhill. Their heads were tilted slightly upward to ensure that the air passage remained open. They were left to recover undisturbed and monitored with telemetry to ensure recovery.

7.2 Grizzly Bear Captures

Due to the delay in obtaining funding and collars for the grizzly bear research in 2001, grizzly bear capture operations did not occur in 2001. The workplan for grizzly bears was subsequently revised to April-May, 2002. During April 2002, Conservation Officers, SRD biologists, and I reviewed sighting data, telemetry data from an ongoing monitoring project of problem grizzly bears with Very High Frequency (VHF) collars, and previous problem bear locations to determine suitable locations for setting traps within the Crowsnest Valley.

Landowners were consulted and permission obtained to set up culvert traps, pail snare sets, and baits (Appendix B). Sites were closed to the public and traps were checked twice per day. All capture operations were conducted with Conservation Officers and included a Bear Response Team Leader (BRTL). Grizzly bears captured in culvert traps were taken to the SRD warehouse for processing and recovery. Grizzly bears captured in pail snares were processed in the field and placed in a culvert trap in a quiet and shaded area for recovery.

Grizzly bears in culvert traps and snares were darted using a Cap-Chur pistol or rifle with Pax-Arms darts or Cap-Chur darts. Hand injections were used when needed once the grizzly bear was effectively immobilized. Darts contained Telazol (Tiletamine HCl/zolazepam HCl) at an intended dosage of 2.7-3.6 mg/lb (6-8 mg/kg). Each individual was hobbled and secured with a snare line to a tree or concrete fixture at the warehouse. An ophthalmic lubricant was placed in the eyes and the eyes were covered. Vital signs (respiration rate and rectal temperature) were monitored every ten minutes throughout the procedure. Darts were removed and wounds and external injuries were examined and treated. Standard morphological measurements were taken and grizzly bears were weighed at commercial weigh stations whilst in the culvert trap. An upper premolar was extracted for age determination where possible. Tissue and hair samples were collected. All bears were ear tagged with standard SRD orange ear tags and fitted with a Televilt GPS-Simplex™ (Model G01-01021) collar. Grizzly bears were left to recover in a culvert trap in a shaded and secure place and released the following day in a closed area. Where possible, release locations were in proximity to capture locations. Collared bears were subsequently monitored with telemetry.

7.3 GPS Collars

Cougars were fitted with a Televilt GPS-Simplex™ collar (Model G01-01022). The choice of telemetry system was based on current research projects on cougars in Canmore (J. Jorgenson 2000, pers. comm.) and in Banff National Park (A. Kortello 2001, pers. comm.) and the trade-off between animal welfare and battery life. Cougar collars weighed 675 g and drop-off mechanisms and batteries for these collars added an extra 145 g and 225 g, respectively. Cougar collars were expected to provide 6,000 positions under ideal conditions (e.g., no terrain or canopy interference). Collars were ordered with a specified neck girth. The GPS sampling protocol was defined for each cougar collar and represented a compromise between battery life and the number of locations desired. Collars were programmed to take a position every 2 hours and provide 15 hours of daily VHF beaconing throughout the six months of battery life. GPS positioning time

was selected at 180 seconds to maximize fix rates given terrain and habitat conditions. Remote downloads were scheduled for January 7-13, February 18-24, April 1-7, and May 6-12. All collars were fitted with a programmed electronic drop-off mechanism (183 days following deployment) and a breakaway cotton spacer as well as activity and mortality monitors.

Grizzly bears were fitted with a Televilt GPS-Simplex™ (Model G01-01021). The choice of telemetry system was based on ongoing grizzly bear research projects in the Foothills (R. Munro 2000, pers. comm.), Canmore (J. Jorgenson 2000, pers. comm.) and Banff National Park (M. Gibeau 2001, pers. comm.). GPS collars weighed 1,000 g and drop-off mechanisms and batteries added an extra 150 g and 660 g, respectively. Grizzly bear collars were expected to collect 12,000 positions under ideal conditions. Collars were ordered for a specific neck girth. GPS collars were programmed to take 18 GPS positions a day and provide 15 hours of daily VHF beaconing. Remote downloads were scheduled for 17-23 June, 12-18 August, and 30 September-6 October. Collars were programmed to turn off after November 17 when it was anticipated that bears would be in their dens. GPS collars were fitted with a cotton breakaway spacer and a programmed electronic drop-off mechanism (365 days following deployment) as well as activity and mortality sensors. One grizzly bear was also fitted with a VHF ear tag transmitter programmed to transmit for 15 hours per day for 500 days (Advanced Telemetry Systems, Isanti, MN).

7.4 Telemetry

Radio locations from the ground were obtained daily after capture operations and weekly thereafter using a portable receiver (Lotek Engineering, 150-151 MHz or Communications Specialists, Inc, 150-152 MHz), roof-mounted omni-directional antennae, and 4-element hand-held H antenna. Locations were determined based on the loudest signal and bearings were collected from 3 positions using a hand-held, 12-channel Garmin GPS receiver (North American Datum 1983). Bearings will be plotted on 1:50,000 scale topographic maps. Activity was inferred from the changes in the collar pulse rates. Ground radio telemetry was supplemented by aerial locations when weather and budgets permitted and prior to scheduled remote download sessions. Collar frequencies were added to ongoing grizzly bear monitoring flights whenever possible.

Remote downloads for cougars were conducted from the ground since the majority of the cougars were relatively inactive during the day when downloads were scheduled and they were often within 1-2 km of a road or trail. Helicopter support was used prior to downloads to pinpoint locations of the cougars. All UTM coordinates prior to and during capture were eliminated to calculate fix rates, the number of 2D and 3D fixes, and successive distance measurements between fixes.

Remote downloads for grizzly bears were conducted with helicopter support. Typically, grizzly bears were located prior to scheduled downloads. Once located, the helicopter was set down within 1-2 km of the bear and shut down. This provided time for the grizzly bear to return to its normal activities and allowed me to position myself for the download. A second receiver was used to monitor the bears' movement during the

download process. All UTM coordinates prior to and during capture were eliminated to calculate fix rates, the number of 2D and 3D fixes, and successive distance measurements between fixes. For collars that remained on the bear and failed, the last fix date was considered the failure date.

GPS data were compiled in EXCEL and imported into ArcView 3.3 GIS. Movement parameters were analyzed using the Animal Movement Extension (http://www.absc.usgs.gov/glba/gistools/animal_mvmt.htm).

8.0 RESULTS AND DISCUSSION

8.1 Cougar Captures

During December 2001 - February 2002, five cougars (three females and two males) were captured and collared with the aid of five local houndsmen (Table 1). We attempted to capture cougars within the study area on both sides of Highway 3. Consequently, we captured two females and one male north of the highway and one male and one female south of the highway. All cougars captured were considered to be adults and > 2 years old. None of the females captured showed evidence of having kittens. All cougars captured were immobilized (Table 2). Four cougars required additional injections to induce immobilization. In these cases, darts failed to discharge or where poorly placed which likely contributed to multiple injections. Based on these results, the intended dosage was considered to be a minimum dosage to immobilize cougars in this study area. The dosage was subsequently adjusted to 6.25 mg/lb (13.75 mg/kg) KHCl and 3.1 mg/lb (6.8 mg/kg) XHCl. The fifth cougar captured at this dosage required a single injection. Pall et al. (1988) initially used the same dosages followed in this study and considered the combination of 11 mg/lb KHCl and 5.5 mg/lb XHCl to be a minimum dosage to immobilize cougars in their study area. They reported using higher dosages on certain individuals (18.2 – 23.1 mg/kg KHCl). The dosages used in this study are higher than those reported by Quigley (2001) who recommended a dosage of 2-5 mg/lb (4-11 mg/kg) KHCl and 0.2-0.5 mg/lb (0.4-1.1 mg/kg) of XHCl.

Subsequently, it was determined that the 2:1 ratio of KHCl and XHCl was not the best cocktail for cougar captures (T. Shury 2002, pers. comm.). Future capture operations will use a 5:1 ratio of KHCl and XHCl at a dosage of 10 mg/kg and 2 mg/kg, respectively.

Induction times were accurately recorded for cougars that remained in the tree after injection. Induction times for cougars that jumped from trees were more difficult to determine accurately as the cat was not observed immediately after injection and typically moved 20-50 m post-injection. In most cases, 10-15 minutes were allowed to pass before tracking the cougar on the ground (20-30 minutes). Immobilization times varied considerably with each individual ranging from 60 minutes to 165 minutes however the longest immobilization time was the result of poor dart placement on initial injection and a second injection that failed to discharge (Table 2). Induction times were reported by Pall et al. (1988) for cougars that were immobilized with one injection. Mean induction time for adult females was 6.8 minutes and immobilization time

averaged 122 minutes. The adult male captured in their study was immobilized for 214 minutes.

Rectal temperature and respiration rate of immobilized cougars averaged 38.9°C and 22 breaths/minute, respectively. These results are consistent with physiological normals reported for cougars (Quigley 2001) but sample sizes were too small to determine if there were any relationships between these parameters and sex-age class, dosage rate, length of chase or whether or not the cougar jumped from the tree on initial injection.

All cougars were measured during the capture operations (Table 3). Males were generally larger than females in most body measurements. Average measurements are comparable to Pall et al. (1988) however both the adult males and females in this study were smaller than those reported in the Sheep River study area. Though sample sizes are small, cougars captured in this study were also smaller than those registered in the Blairmore and Pincher Creek offices (Table 4). Hair and tissue samples were collected for all cougars but blood samples could not be collected due to difficulties locating the femoral vein.

Table 1. Cougar capture data in the Crowsnest Pass, AB, 2001/02.

ID	Sex	Age Class	Age (months)[1]	Weight (kg)	Date	Capture Location
CROWCO1	F	ADULT	27	48	December 10, 2001	Hillcrest
CROWCO2	M	ADULT	30	58	December 14, 2001	East Hwy 940
CROWCO3	F	ADULT	N/A[2]	45	December 17, 2001	Forestry Reserve
CROWCO4	M	ADULT	33	55	January 22, 2002	York Creek
CROWCO5	F	ADULT	19	45	February 2, 2002	North of Blairmore

[1] Using gum-line recession calculation Age (months) = 1.7+15.67 x Gum recession (mm) (Laundre et al. 2000)
[2] Could not clearly detect a recession line

Table 2. Dosages administered and induction and immobilization times of cougars in the Crowsnest Pass, AB.

ID	Sex	Actual Dosage (mg/lb)	Induction Time (min)	Immobilization Time (min)	No. Injections	Comments
CROWCO1	F	10	10	42	2	Remained in tree
CROWCO2	M	11.7	N/A[1]	75	3	Did not receive full dose on 2nd injection
CROWCO3	F	12.2	N/A[1]	52	2	Did not respond well to drugs
CROWCO4	M	12.3	N/A[1]	165	3	Initial injection poorly placed; 2nd injection did not discharge
CROWCO5	F	13	N/A[1]	31	1	Induction and immobilization were smooth

[1] Induction times could not be accurately determined as the cat jumped from the tree and was not observed for 20-30 minutes until located

Table 3. Body measurements of five cougars captured in the Crowsnest Pass, AB.

Measurement	Adult Males (n=2)[1]	Adult Female (n=3)[1]
Low Neck Circumference[2]	44.65 ± 0.21	40.27 ± 1.1
Body Length[2]	123.6 ± 20.65	125 ± 3.3
Tail Length[2]	75.1 ± 20.36	78.8 ± 4
Total Length[2]	194.7 ± 5.94	203.8 ± 0.72
Chest Girth[2]	77.2 ± 1.41	71.43 ± 1.07
Skull length[2]	26.7 ± 0.85	28.57 ± 4.89
R. front pad width[3]	53 ± 3.96	51.47 ± 9.02
R. front pad length[3]	38.35 ± 5.02	39.6 ± 7.98
R. hind pad width[3]	43.1 ± 0.99	45.37 ± 1.27
R. hind pad length[3]	36.95 ± 7.42	34.7 ± 8.81
L. front pad width[3]	52 ± 13	47.43 ± 3.79
L. front pad length[3]	39.05 ± 5.87	35.77 ± 3.32
L. hind pad width[3]	43.75 ± 3.61	40.5 ± 2.44
L. hind pad length[3]	37.1 ± 5.23	32.33 ± 1.65
Upper canine width @ tips[3]	41.6 ± 0.42	43.6 ± 9.56
Upper canine width @ base[3]	34.7 ± 5.66	41.17 ± 15.36
Lower canine width @ tips[3]	33.7 ± 0.42	32.23 ± 2.91
Gumline recession upper canine[3]	1.9 ± 0.14	1.35 ± 0.35
Gumline recession lower canine[3]	1.1 ± 0.28	0.85 ± 0.21
Weight[4]	56.82 ± 1.93	45.91 ± 1.64

[1] average ± standard deviation
[2] cm
[3] mm
[4] kg

Table 4. Body measurements of cougars registered in Blairmore and Pincher Creek offices.

Measurement	Male Adult (n=5)	Female Adult (n=1)
Low Neck Circumference[1]	54	30
Body Length[1]	130	126
Tail Length[1]	75	80
Total Length[1]	207	206
Chest Girth[1]	81	72
Skull length[1]	28	
R. front foot width[2]	57	50
R. front foot length[2]	39	40
R. hind foot width[2]	47	40
R. hind foot length[2]	41	30
L. front pad width[2]	57	50
L. front pad length[2]	45	40
L. hind foot width[2]	50	40
L. hind foot length[2]	43	35
Upper canine width @ tips[2]	52	40
Upper canine width @ base[2]	58	50
Lower canine width @ tips[2]	41	35
Gumline recession upper canine[2]	2	
Weight[3]	64	45.5

[1] cm
[2] mm
[3] kg

8.2 Grizzly Bear Captures

A maximum of five bait sites were set from April through June, 2002. These were rotated based on sightings and accessibility and were set on both sides of Highway 3. Each site consisted of a minimum of one culvert trap and two pail snares. Traps were checked in the early morning and early evening and were closed during heavy snowfall, cold overnight temperatures, or when Conservation Officers and the BRTL were required to be away from the study area. Bait sites were re-established opportunistically throughout the summer and fall based on sightings and local reports.

During April-June 2002, two male grizzly bears were captured and collared (Table 5). Both males were adults and > 5 years old. One male was captured in a culvert trap north of Highway 3 and the second in a pail snare south of Highway 3. The male captured in a culvert trap had previously been captured as part of the problem bear monitoring program and the only individual in that dataset that used the study area. He had radio ear tags still in place and appeared to have a damaged right front foot. Both males were immobilized (Table 6). Induction times and immobilization times were similar (Table 7).

Rectal temperature and respiration rates of immobilized grizzly bears averaged 39.6 °C and 56 breaths/minute, respectively. Hair and tissue samples were collected but blood samples could not be collected due to difficulties locating the femoral vein.

Black bears inadvertently captured during trapping operations were released in WMU 402. Black bears caught in snares were immobilized, ear tagged with a standard orange DO NOT EAT tag and a research tag and standard measurements were collected. Black bears were allowed to recover in a culvert and released in WMU 402 with aversive conditioning measures such as dogs and bear bangers.

Table 5. Grizzly bear capture data in the Crowsnest Pass, AB, 2002.

ID	Sex	Age Class	Weight (kg)	Date	Capture Location
CROWGB1	M	ADULT	275	April 29, 2002	East of Allison Creek Road
CROWGB2	M	ADULT	200	June 7, 2002	Adanac Road

Table 6. Dosages administered and induction and immobilization times of grizzly bears captured in the Crowsnest Pass, AB.

ID	Sex	Actual Dosage (mg/kg)	Induction Time (min)	Immobilization Time (min)	No. Injections	Comments
CROWGB1	M	9	12	~240	4	First injection did not discharge
CROWGB2	M	5	6	100	1	Induction and immobilization were smooth

Table 7. Body measurements of two grizzly bears captured in the Crowsnest Pass, AB.

Measurement	Adult Males (n=2)[1]
Neck Circumference[2]	88
Body Length[2]	203.5 ± 0.7
Chest Girth[2]	136.5 ± 10.6
Belly Girth[2]	173 ± 9.9
L. front pad width[3]	116.4 ± 5.1
L. front pad length[3]	65.1 ± 10.5
L. hind pad width[3]	115.2 ± 0.2
L. hind pad length[3]	181.5 ± 29
Intercanine distance:Top[3]	64.9
Intercanine distance: Bottom[3]	54.8
Weight[4]	237.5 ± 53

[1] average ± standard deviation
[2] cm
[3] mm
[4] kg

8.3 Telemetry

NOTE: The following results are preliminary and are subject to change in future documents and publications. More data will be acquired for the remaining collared grizzly bear as data are missed during remote downloads.

GPS collars appeared to fit well with the antennae in a dorso-central position. This positioning affects the performance of the GPS antennae. In addition, canopy and terrain features may also block the antennae. Because there was no previous information on movement rates or ecology of the cougars or grizzly bears in the study area, it was difficult to determine if the collars affected their normal behaviour patterns.

8.3.1 Cougar GPS Data

A female cougar was shot during February and her collar was badly damaged (**CROWCO3**) (Appendix A). Televilt engineers were able to recover the data from this collar resulting in 413 fixes during December 17, 2001 and February 14, 2002 (Appendix D). Her home range during this time was determined to be 69 sq km based on a 100% minimum convex polygon (MCP) (Appendix C). On May 2, 2002, a male cougar (**CROWCO4**) slipped his collar. Six hundred and ninety-nine fixes were obtained from January 22 until May 2, 2002 (Appendix D). His home range during this time was determined to be 216 sq km based on a 100% MCP (Appendix C). In August, attempts were made to recapture one female (**CROWCO5**) to replace her collar. Capture operations were unsuccessful and the collar dropped off as scheduled. One thousand, one hundred and ninety-one fixes were obtained during February 2 and August 9, 2002 (Appendix D). Her home range during this time was determined to be 149 sq km based on a 100% MCP (Appendix C). These winter home ranges are comparable to the literature. Spreadbury et al. (1996) reported a mean female home range of 31 ± 10 km^2 during December-March. The only male in their study had a home range of 172 km^2. Fix data for these three cats are summarized in Table 8. GPS positioning time for

CROWCO3, **CROWCO4**, and **CROWCO5** (180 seconds) appeared to be adequate. Collars obtained 99.76%, 100%, and 99.92% of all fixes within 180 seconds (Appendix E). Approximately 50% of the total fixes were obtained within 50 seconds.

Table 8. Summary of Cougar GPS Collar Data, 2001/02.

	Date		Number of Fixes		Percent	Percent of	
Cougar ID[1]	GPS Start	GPS End	Possible	Attained	Fix Rate (%)	2D Fixes	3D Fixes
CROWCO3	December 17, 2001	February 14, 2002	720	413	57	63	37
CROWCO4	January 22, 2002	May 2, 2002	1188	699	59	55	45
CROWCO5	February 2, 2002	August 9, 2002	2268	1191	53	70	30

[1] All collars were retrieved

CROWCO5 was the only cougar in this study that crossed Highway 3. She crossed the highway twice: 1) February 4, 2002 at 02:16; and, 2) August 8, 2002 between 16:15 and 18:17. During the first crossing, she stayed south of Highway 3 for over a day before returning north. During the second crossing, she stayed south of Highway 3 for less than 8 hours. Both crossings occurred northeast of Blairmore.

Two collars failed. The VHF signals on a female (**CROWCO1**) and male (**CROWCO2**) cougar collar ceased to function after 2 and 5 months, respectively. This occurred despite adequate testing prior to deployment. Collars appeared to be functioning normally prior to failure. These collars were not recovered despite extensive telemetry flights to locate them and on-the-ground reconnaissance with hounds. Remote downloads, prior to failure, were unsuccessful. In future, collars will be fitted with a modified ear tag transmitter to provide a second VHF antennae system in the event of failure of the VHF on the GPS collar. This will add an additional 22 g of weight and should permit collar retrieval after drop-off and/or recapture of the cougar if necessary. It was speculated that the collars failed due to a malfunction between the GPS unit and the battery pack. Other projects have reported that the O-ring between the battery pack and GPS collar can slip and/or degrade permitting moisture to enter the battery pack and disrupt collar function (L. Ciarniello, pers. comm., Ciarniello et al. 2002). Because the collars could not be retrieved to confirm this for my study, a layer of commercial silicone will be applied to the inside edge of each secured battery pack in subsequent collaring operations.

As described above, cougar collars were programmed to take a position every 2 hours. Given the battery size, this allowed for 6 months of data collection with scheduled VHF beaconing and remote download requirements. It was anticipated that cougars would be recaptured in the summer to apply a new collar and continue data collection thereby providing one year of data on each cat. This summer however confirmed that this would not be feasible. The houndsmen have never tracked cougars on the ground in the summer and the capture attempts were difficult and dangerous for both the personnel and the cat. To address this, the scheduled GPS positioning programs for cougars will be changed to one position every four hours. This provides a calculated 346 days of battery life and eliminates the need for mid-year recaptures. Data collected during 2001/02 on the 2-hour schedule will be re-sampled to every 4 hours for the subsequent analyses and comparison.

8.3.2 Grizzly Bear GPS Data

The GPS collar on one male (**CROWGB1**) was detected as "malfunctioning" on July 22, 2002. The VHF signal emitted was a triple beat "chirp". The collar did not have any activity pulse changes and could not be localized very easily. During a scheduled remote download, it was determined that the collar was no longer functioning (e.g., did not turn off when GPS was being taken, did not have mortality or activity pulse rate, did not transmit a low battery/failure pulse rate) and it was retrieved on the ground on August 12, 2002. The grizzly bear had slipped the collar off its head but it was unclear how long the collar had been on the bear in a malfunctioning state. Five hundred and eighty fixes were obtained from the date of collaring (April 30, 2002) until the last collar fix and presumed collar failure (June 10, 2002) (Appendix F). His home range during this time was determined to be 1,036 sq km based on 100% MCP. He remained in the study area for 2 days (post-release) during this time. GPS positioning time for **CROWGB1** and **CROWGB2** (180 seconds) appeared to be adequate. Collars obtained 100% of all fixes within 180 seconds (Appendix G). Approximately 70% of the total fixes were obtained within 50 seconds.

Despite extensive telemetry efforts, the second male (**CROWGB2**) could not be located until the third and final scheduled download. During this reporting period, 655 locations were obtained during August 13 and October 1, 2002 (Appendix F). His home range during this time was determined to be 719 sq km based on 100% MCP. It is anticipated that additional data will be obtained when the collar is retrieved next June. Fix rates are summarized in Table 9.

The reason for the collar malfunction was unclear. The collar had been tested extensively and sent back to Sweden prior to deployment because of difficulties with programming. All of these tests indicated that the collar was in good working order. The collar was not damaged by the bear and there appeared to be no compromise in the seal between the battery pack and collar. This pattern of failure has been reported in other studies using the same GPS collars (L. Ciarniello 2001, pers. comm., Ciarniello et al. 2002). The collar has been sent back to Sweden for further testing.

As with cougars, future collars will be fitted with a modified VHF ear tag transmitter to provide a backup in the event of GPS collar failures. Ear tags add an additional 22 g to the collar and are located close to the drop-off mechanism so they do not interfere with the position of the GPS antennae. We suspect that the ear tag antenna will be damaged during the year, but ear tags will be recovered with the collar when it is retrieved either due to drop-off or rot off of the spacer. In addition, battery packs will be sealed with silicone to retard moisture and possible O-ring failures.

Table 9. Summary of Grizzly Bear GPS Data.

	Date		Number of Fixes		Percent	Percent of	
Grizzly Bear ID	GPS Start	GPS End	Possible	Attained	Fix Rate (%)	2D Fixes	3D Fixes
CROWGB1[1]	April 30, 2002	June 10, 2002	756	580	77	49	51
CROWGB2[2]	August 13, 2002	October 1, 2002	900	699	78	50	50

[1] Collar retrieved

[2] Only third download report available for fix rate information

9.0 MANAGEMENT IMPLICATIONS AND FUTURE DIRECTION

Local land management authorities (municipalities, municipal districts, and the provincial government) and conservation organizations require empirical data and predictive tools to make and support land-use decisions that affect ecological connectivity for carnivores and their prey in areas with escalating development pressures. By developing robust models of movement and resource selection for grizzly bears and cougars, wildlife corridors can be located and quantified within the study area. The results of this project will be used to inform and support on-the-ground land-use decision-making by habitat management agencies and conservation organizations such as the Alberta Conservation Association (ACA), Nature Conservancy of Canada (NCC), and SRD. For example:

- Habitat and movement models developed for grizzly bears and cougars will identify and validate critical wildlife areas based on habitat selection and movement patterns. This information could focus **habitat retention and protection** efforts currently being pursued by organizations such as NCC, ACA, and SRD. This includes securing habitat through purchases, easements, landowner agreements, and crown land reservations as well as maintaining corridors for these populations at a regional scale. This will allow conservation values to be retained on crown lands and complement those afforded by existing protected areas in Alberta such as Waterton National Park. Products from this research such as maps of movement and habitat selection should be useful tools to facilitate discussions with landowners in these efforts.
- The GIS-based models developed in this research can be used to address **habitat enhancement** efforts such as burns, whether natural or prescribed, to improve elk winter ranges, vegetation manipulations and silvicultural treatments and their effects on carnivores. By building these habitat manipulations into our models, we can anticipate the consequences of these management efforts and use these results to identify habitats for enhancement, retention, and protection. We can predict the consequences of alternative habitat management schemes on the populations in the study areas.
- The models can help define the optimal locations and assess the utility of **wildlife habitat and movement corridors**, particularly in the Crowsnest Pass. These corridors have application to local and regional connectivity for populations using adjacent protected areas.
- Finally, the models may assist managers in developing scientifically based **mitigation options** for anticipated highway twinning and expansion projects in critical wildlife habitats, particularly in the Crowsnest Pass area.

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11.0 PERSONAL COMMUNICATIONS

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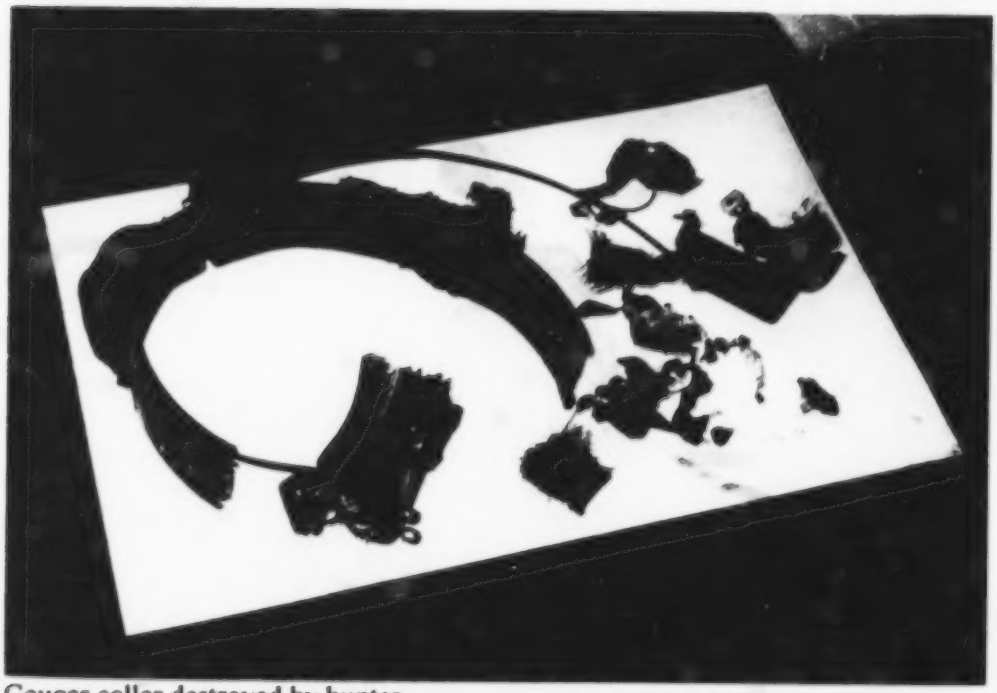
12.0 APPENDICES

Appendix A – GPS Collars Used on Cougars in the Crowsnest Pass, AB

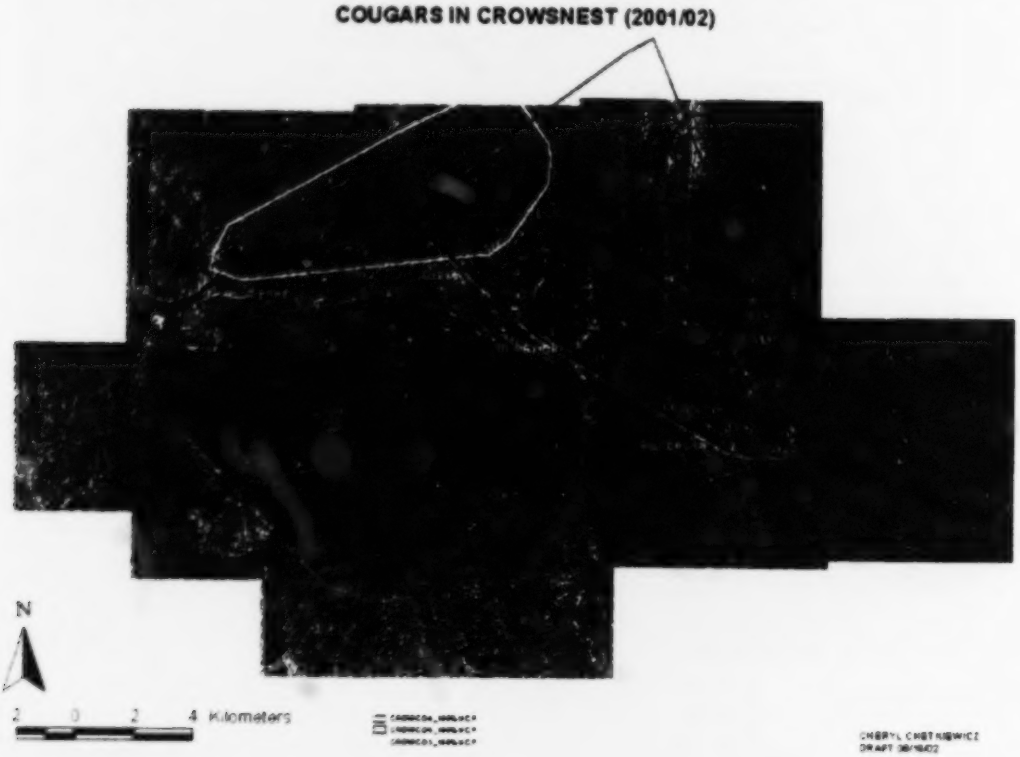


Cougar collar destroyed by hunter

Appendix B – Typical Trap Site for Grizzly Bears

Typical trap site for grizzly bears including culvert trap, pail snare, and bait station.

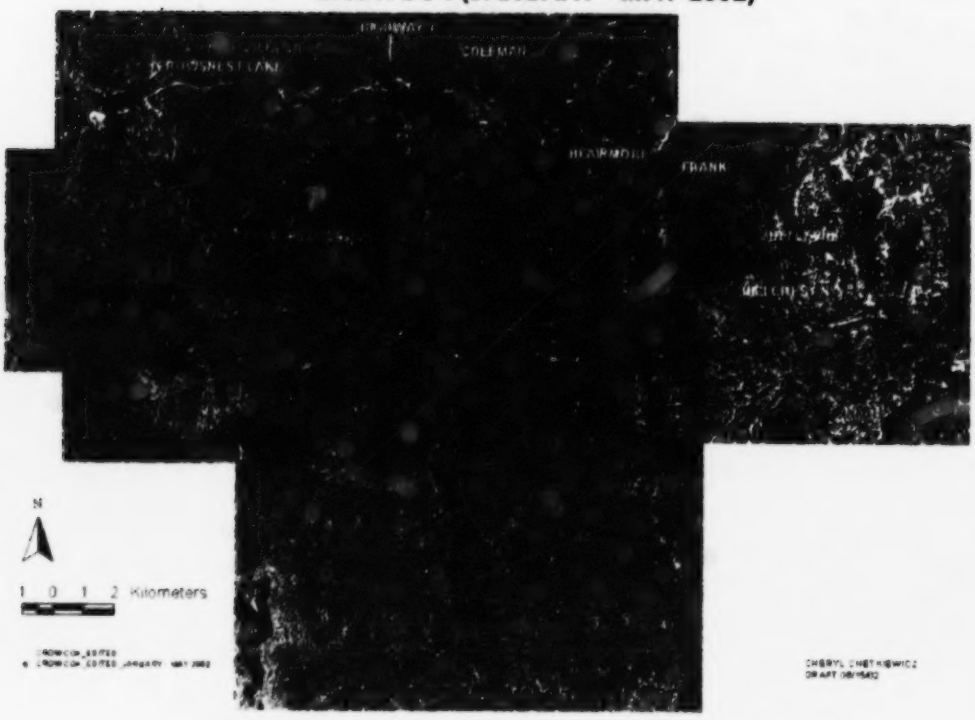
Appendix C – Seasonal Home Ranges for Cougars Captured in Crowsnest Pass, AB



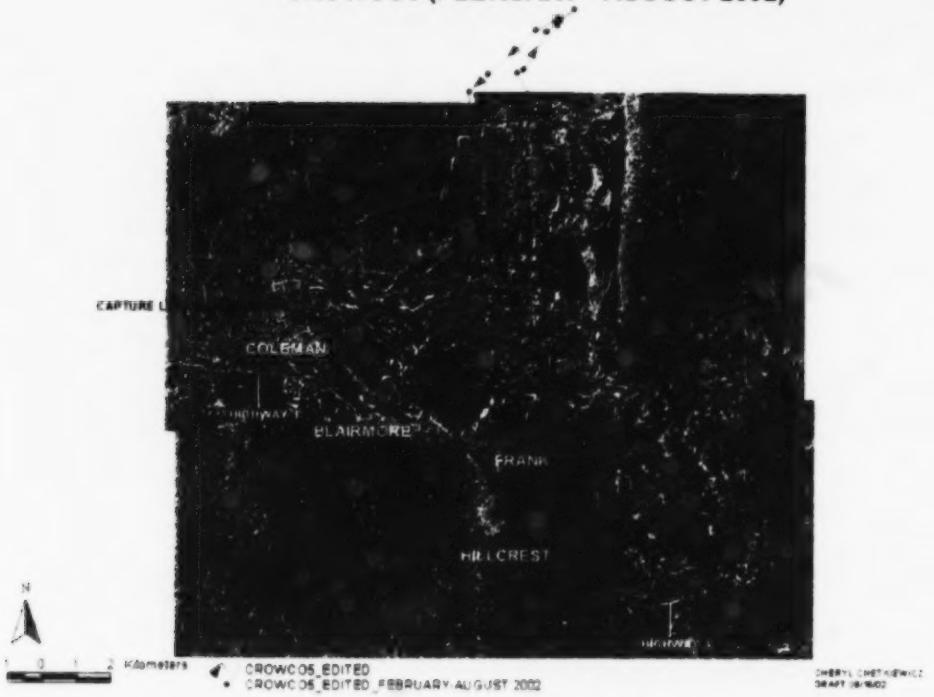
Appendix D – Movement Data from Cougars in the Crowsnest Pass, AB

CROWCO3 (DECEMBER 2001 - FEBRUARY 2002)

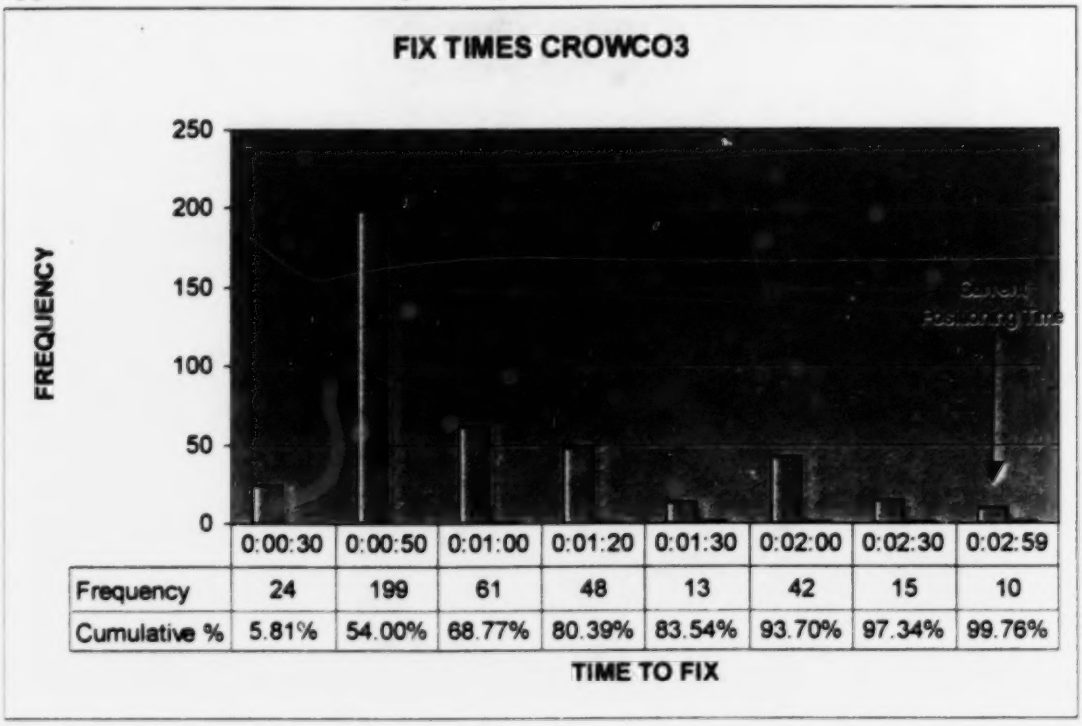
CROWCO4 (JANUARY - MAY 2002)



CROWCO5 (FEBRUARY - AUGUST 2002)

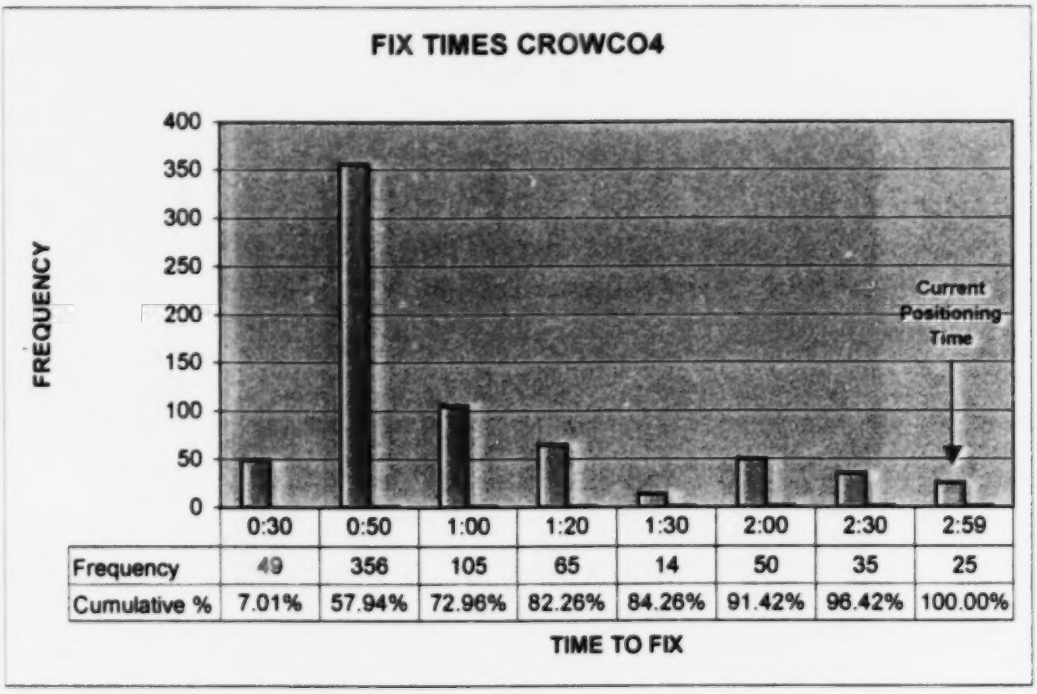


Appendix E – Fix Times for Cougars Captured in Crowsnest Pass, AB



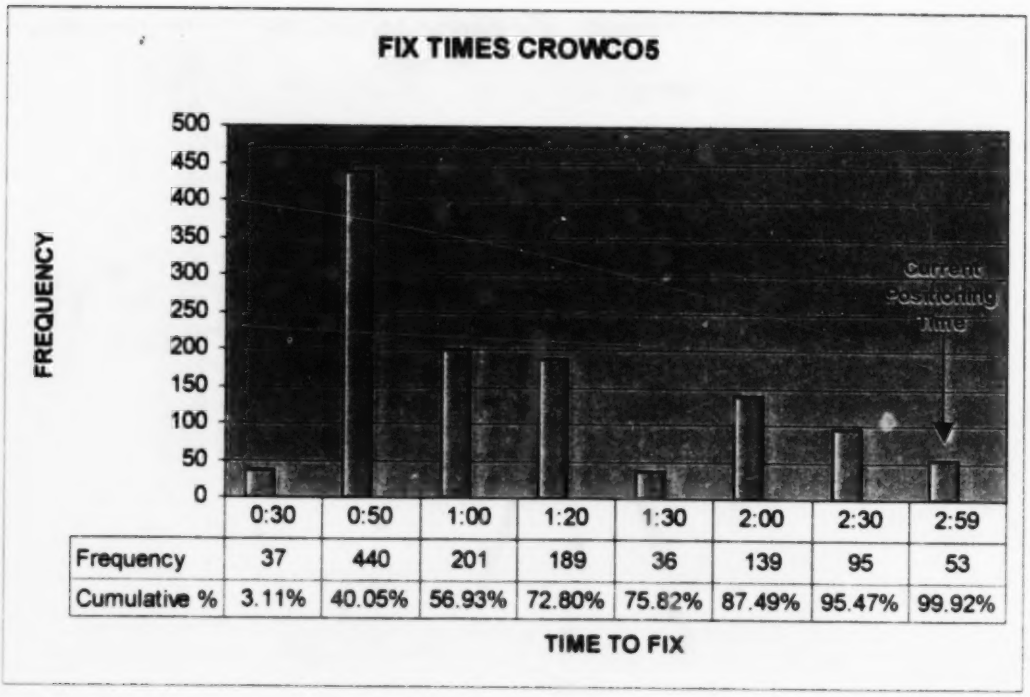
	0:00:30	0:00:50	0:01:00	0:01:20	0:01:30	0:02:00	0:02:30	0:02:59
Frequency	24	199	61	48	13	42	15	10
Cumulative %	5.81%	54.00%	68.77%	80.39%	83.54%	93.70%	97.34%	99.76%

TIME TO FIX



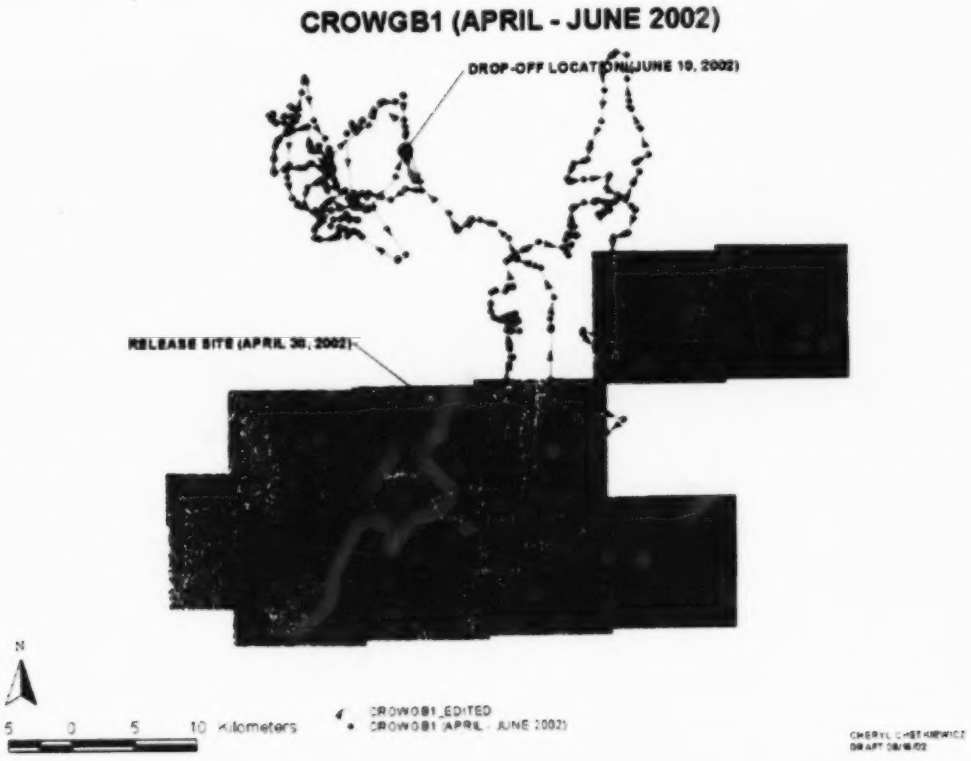
	0:30	0:50	1:00	1:20	1:30	2:00	2:30	2:59
Frequency	49	356	105	65	14	50	35	25
Cumulative %	7.01%	57.94%	72.96%	82.26%	84.26%	91.42%	96.42%	100.00%

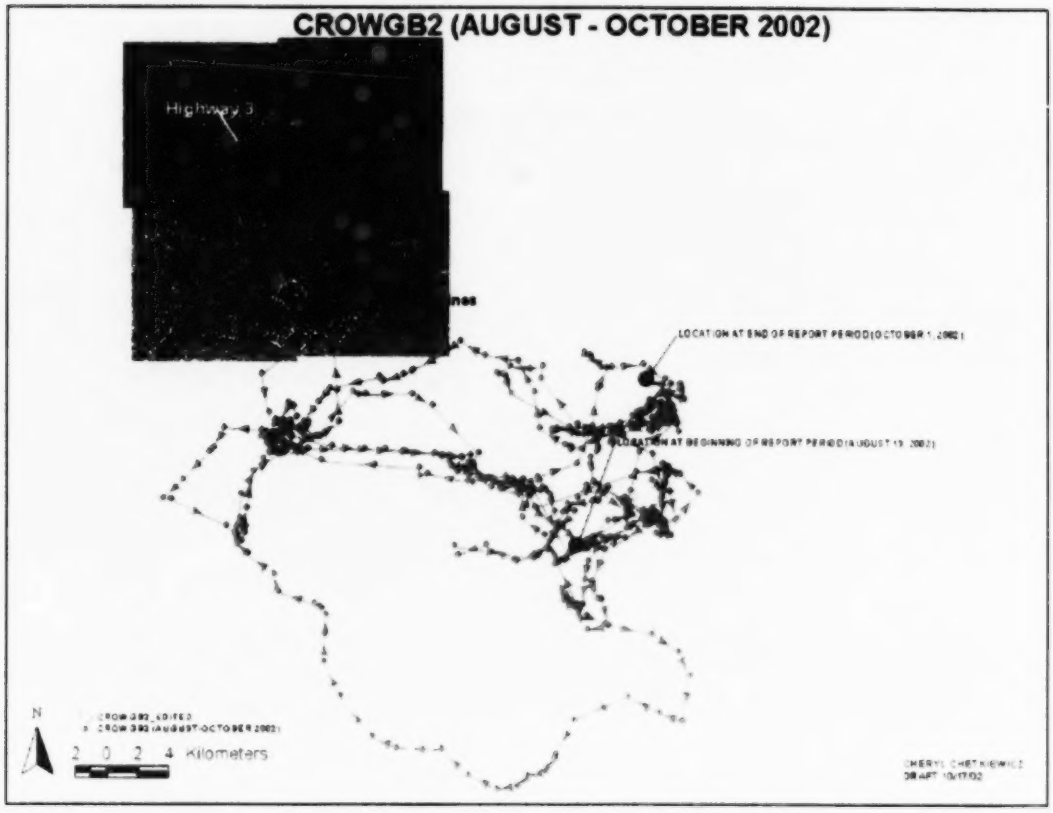
TIME TO FIX



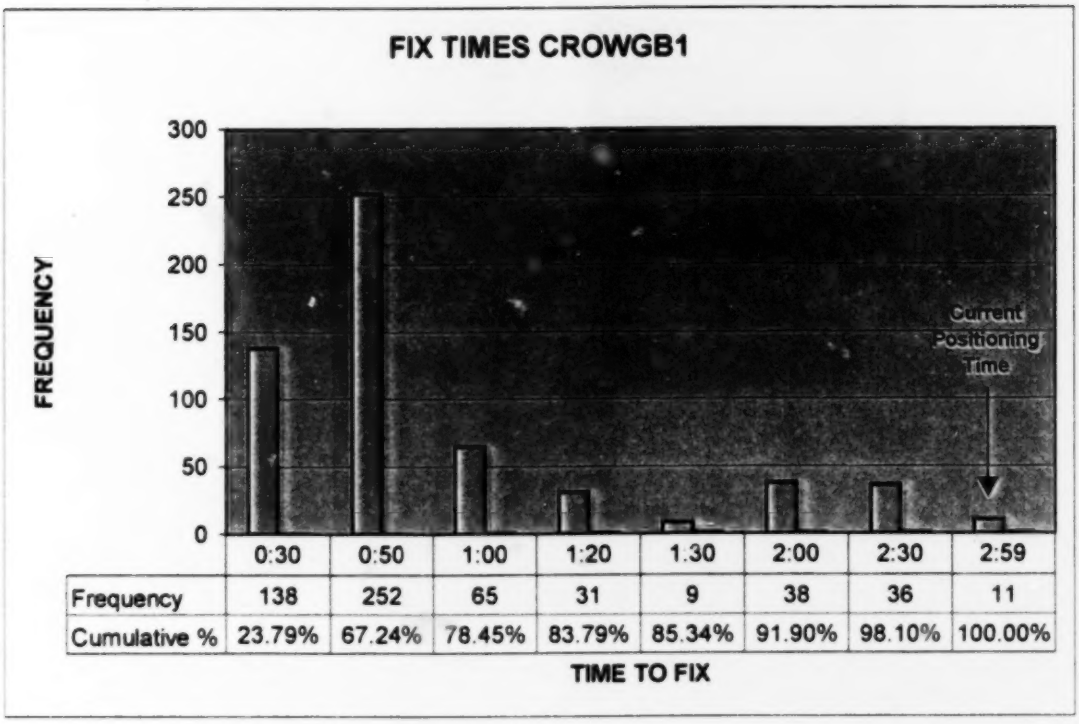
	0:30	0:50	1:00	1:20	1:30	2:00	2:30	2:59
Frequency	37	440	201	189	36	139	95	53
Cumulative %	3.11%	40.05%	56.93%	72.80%	75.82%	87.49%	95.47%	99.92%

Appendix F – Movement Data from Grizzly Bears Captured in Crowsnest Pass, AB

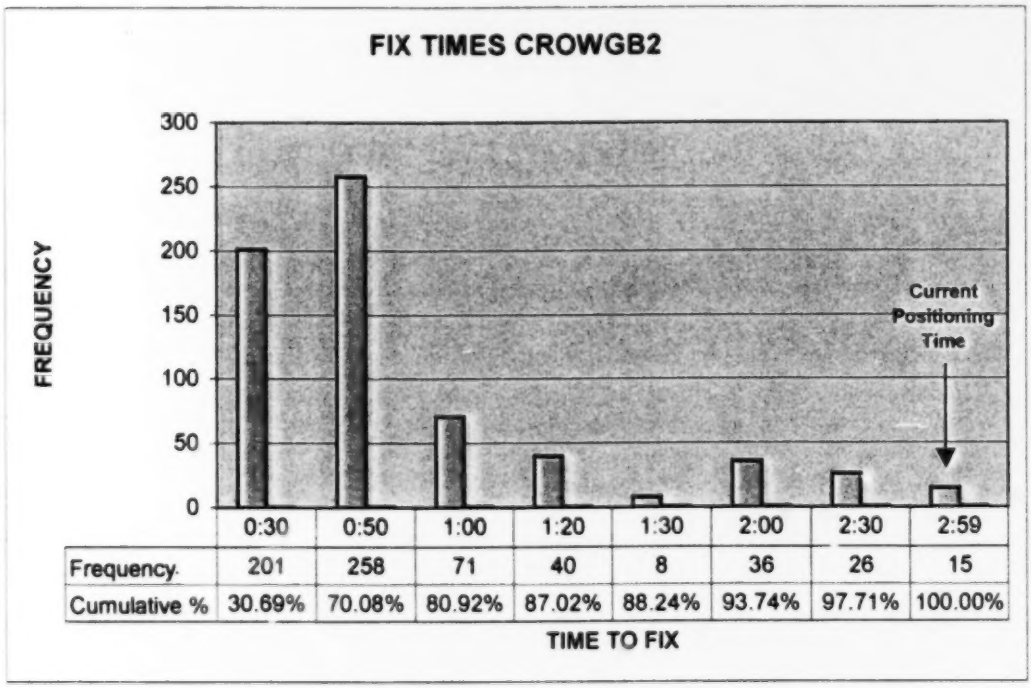



CROWGB2 (AUGUST - OCTOBER 2002)
Highway 3
N
2 0 2 4 Kilometers

Appendix G – Fix Times for Grizzly Bears Captured in Crowsnest Pass, AB



	0:30	0:50	1:00	1:20	1:30	2:00	2:30	2:59
Frequency	138	252	65	31	9	38	36	11
Cumulative %	23.79%	67.24%	78.45%	83.79%	85.34%	91.90%	98.10%	100.00%



	0:30	0:50	1:00	1:20	1:30	2:00	2:30	2:59
Frequency	201	258	71	40	8	36	26	15
Cumulative %	30.69%	70.08%	80.92%	87.02%	88.24%	93.74%	97.71%	100.00%

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(as of March 2002)

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